

written in his usual clear and popular manner, but the prevailing impression is decidedly that of disproportion. Too much space is occupied by the personalities which were unfortunately too frequently shown in his controversial methods, and by details of a comparatively unimportant character; while essentials are, as we have pointed out, frequently incompletely dealt with or even entirely omitted.

Mr. Ranyard's portion is admirably written, is very thoughtful and suggestive, and is a valuable contribution to our knowledge of the stellar universe and the condition and distribution of matter in external space. Indeed, the comparative brevity of this portion of the book is its chief fault, and a condensation of the earlier portion to allow of the expansion of this would greatly increase its value to the student, and would certainly not lessen its interest to the general reader.

A. T.

EARTHQUAKES.

Erdbebenkunde. Die Erscheinungen und Ursachen der Erdbeben, die Methoden ihrer Beobachtungen. Von Dr. Rudolf Hoernes, o.ö. Professor der Geologie und Paläontologie an der Universität Graz. (Leipzig: Veit and Co., 1893.)

Etude sur les Tremblements de Terre. Par Léon Vinot. (Paris and Nancy: Berger-Levrault et Cie, 1893.)

IN a recent article in this journal, entitled "Seismology in Japan" (see NATURE, June 8, p. 136) attention was directed to the long series of memoirs which deal with the methods and results of earthquake-observation, and have appeared in the Transactions of the Seismological Society of Japan, or its successor, the *Seismological Journal of Japan*. Any advance in our knowledge of the phenomena or causes of earthquakes resulting from the study of the frequently occurring shocks in Japan is largely due to the untiring efforts of the editor of those journals, Prof. John Milne, and to those of the school of active seismologists, whom he has educated and inspired with some of his own enthusiasm. We can best judge, perhaps, how far advances of our knowledge on this difficult and obscure department of physics and geology have been real and of permanent value from the examination of text-books and general treatises, in which summaries are given of the latest and most important researches upon the subject.

The two works whose titles appear at the head of this article, and which have recently made their appearance in Germany and France respectively, may well serve the purpose of illustrating what is the high-water mark of our knowledge at the present time concerning these remarkable but little understood phenomena.

If we compare these two books with their numerous predecessors, the first peculiarity which strikes us is the classification of earthquake-phenomena, based on the supposed causes of the disturbance of equilibrium in the earth's solid crust, which have been adopted by the recent authors. While the older writers took for granted the close connexion between seismological and vulcanological phenomena, so that "earthquakes and volcanoes" were almost always discussed in the same treatise, the two works before us afford distinct evidence that this

conviction has now been very seriously shaken. It is true that nearly all great volcanic outbursts have been attended by earth-tremblings; but it is equally true that some of the grandest displays of seismic energy have occurred in areas that have not at any recent period been the scenes of volcanic activity; and both the German and the French author admit the existence of great classes of seismic disturbances, which have no necessary connexion with any manifestations of volcanic energy.

Dr. Hoernes classifies earthquakes under the four headings: "Vulkanische Beben," "Einsturzbeben," "Dislocationsbeben," and "Relaisbeben." M. Vinot treats of them under the following heads:—"Tremblements de terre suivis, d'éruptions où liés directement à l'action volcanique;" "Tremblements de terre dus encore à l'action direct du feu central, mais sans manifestation consécutive du volcanisme;" and, lastly, "Tremblements de terre indépendant de l'action volcanique."

But with this recognition of the class of non-volcanic earthquakes the resemblance between these two books ceases. Dr. Hoernes commences his work with an admirable account of the speculations on the nature and causes of earthquake-phenomena which have appeared from the earliest times. His comprehensive sketch begins with extracts from the writings of Hebrew prophets and Greek philosophers, and ends with references to the Seismological Society of Japan. The two chapters which follow on earthquake-phenomena and earthquake-observation are clear and useful summaries of the most recent researches on the subject, and are well brought up to date. Supplied as they are with drawings and descriptions of seismographic apparatus, they afford one of the best guides with which we are acquainted to a general knowledge of the principles and methods of seismological investigation.

M. Vinot commences his work with a chapter on the nebular hypothesis and the proofs of the existence of central heat within the earth. He insists that, to explain the phenomena of earthquakes, it is necessary to assume the existence at a depth which certainly does not exceed "quelques centaines des kilomètres," of a mass of incandescent liquid materials, which he argues must consist of molten metals in which are dissolved certain gases. The subsequent chapters of his book are a series of deductions from these premises. It will thus be seen that the methods and plan of the German and French authors are about as diverse as can well be conceived. The German work abounds with references by means of which the student who is not satisfied with the summary statements in the text is enabled to put himself into communication with the memoirs of the original investigator whose views have been cited. The French work is simply a readable essay, in which we have none of these valuable aids to study. The illustrations of M. Vinot's book consist of several page plates, reproduced from photographs, and representing the now-destroyed terraces of Rotomahana in New Zealand and the country affected by the eruption of Tarawera but the connexion of these illustrations with the text is by no means obvious.

In two works so diverse in their plan and execution as are those before us, it is interesting to note yet another and somewhat unexpected feature which they present in

common. That M. Vinot should commence his book with references to the Deluge, the destruction of Sodom and Gomorrah, and the giving of the law on Sinai, seems perfectly natural. But most readers will note with some surprise that the last chapter of Dr. Hoernes's book is one entitled "Die Sintfluth." We cannot but regard it as a remarkable testimony to the profound influence of that striking and suggestive book of Dr. Suess, "Das Antlitz der Erde," that this chapter should have been added by Dr. Hoernes to his systematic treatise on Earthquakes. It is scarcely necessary to point out that the flood to which the Austrian geologist devotes the final chapter of his treatise is the deluge, not of Sir Henry Howorth, but of Noah and Hasis-Adra, and that the connexion between this final chapter and the preceding ones is of the very slenderest character. But the legends of our own childhood, and of the childhood of our race have a fascination for us, which neither the brilliant French essayist nor the painstaking German professor seem to have been able to resist.

OUR BOOK SHELF.

The Points of the Horse. By M. Horace Hayes, F.R.C.V.S. (London: W. Thacker and Co., 1893.)

It is certainly curious that although the English nation justly prides itself on its knowledge of horse flesh, and its success in producing the various equine breeds, it should possess no work dealing in an exact and scientific manner with the conformation of the animal that it has done so much to improve. That certain shapes are indicative of great speed, whilst others point to strength rather than speed, has, of course, always been insisted upon in a general way, but it has been left to Captain Hayes to imitate the example of several French authors, and deal with the subject in a scientific spirit. A soldier, a certificated veterinarian, a traveller, and a successful rider, the author is well qualified to treat of all that pertains to the subject before us. The work represents a painstaking endeavour to discover and explain the various principles which govern the make and shape of the horse.

Starting with a study of animals like the Indian black buck and cheetah, which possess terrific speed, he compares them with others such as the buffalo and rhinoceros, which are examples of great strength, a comparison which leads to the conclusion that animals of great strength are distinguished by a long body and short legs; those of great speed by a short body and long legs. This is an exemplification of Marey's law that muscles of speed are long and slender, and those of strength short and thick. Whether it was necessary to stray so far from home to find examples of this fact may be doubted. The thoroughbred racehorse on the one hand, and the massive carthorse on the other, are surely sufficiently contrasted types of speed and strength, whilst between the two extremes are numerous examples exhibiting the union of these two attributes in various degrees, the hunter, for example, uniting considerable strength with moderate speed.

The defects as well as many of the beauties of conformation are admirably depicted in a series of photographs, such defects as turned-in and turned-out toes, sickle-shaped hocks, and upright pasterns, being particularly good. The photographic plates, of which there are over seventy, certainly constitute an important feature in the work, embracing, in addition to the above, portraits of many celebrated racers, notably "Ormonde" and "St. Simon," as well as horses and ponies of various breeds found in

different parts of the globe. A chapter is devoted to an examination of these photographs, the leading features and points of the animals represented being analysed and commented upon. It would be unfair in this connection to omit favourable mention of the 200 excellent drawings by the late J. H. Oswald Brown, which serve throughout the work to illustrate the letterpress.

Author, artist, and publisher have successfully united in producing a first-rate work, which may be cordially recommended to all lovers—and their name is legion—of the horse.
W. F. G.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

Quaternions and Vector Analysis.

IN a paper by Prof. C. G. Knott on "Recent Innovations in Vector Theory," of which an abstract has been given in NATURE (vol. xlvii. pp. 590-593; see also a minor abstract on p. 287), the doctrine that the quaternion affords the only sufficient and proper basis for vector analysis is maintained by arguments based so largely on the faults and deficiencies which the author has found in my pamphlet, "Elements of Vector Analysis," as to give to such faults an importance which they would not otherwise possess, and to make some reply from me necessary, if I would not discredit the cause of non-quaternionic vector analysis. Especially is this true in view of the warm commendation and endorsement of the paper, by Prof. Tait, which appeared in NATURE somewhat earlier (p. 225).

The charge which most requires a reply is expressed most distinctly in the minor abstract, viz. "that in the development of his dyadic notation, Prof. Gibbs, being forced to bring the quaternion in, logically condemned his own position." This was incomprehensible to me until I received the original paper, where I found the charge specified as follows: "Although Gibbs gets over a good deal of ground without the explicit recognition of the complete product, which is the difference of his 'skew' and 'direct' products, yet even he recognises in plain language the versorial character of a vector, brings in the quaternion whose vector is the difference of a linear vector function and its conjugate, and does not hesitate to use the accursed thing itself in certain line, surface, and volume integrals" (Proc. R.S.E., Session 1892-3, p. 236). These three specifications I shall consider in their inverse order, premising, however, that the *epitheta ornantia* are entirely my critic's.

The last charge is due entirely to an inadvertence. The integrals referred to are those given at the close of the major abstract in NATURE (p. 593). My critic, in his original paper, states quite correctly that, according to my definitions and notations, they should represent dyadics. He multiplies them into a vector, introducing the vector under the integral sign, as is perfectly proper, provided, of course, that the vector is constant. But failing to observe this restriction, evidently through inadvertence, and finding that the resulting equations (thus interpreted) would not be true, he concludes that I must have meant something else by the original equations. Now, these equations will hold if interpreted in the quaternionic sense, as is, indeed, a necessary consequence of their holding in the dyadic sense, although the converse would not be true. My critic was thus led, in consequence of the inadvertence mentioned, to suppose that I had departed from my ordinary usage and my express definitions, and had intended the products in these integrals to be taken in the quaternionic sense. This is the sole ground for the last charge.

The second charge evidently relates to the notations Φ_s and Φ_x (see NATURE, vol. xlvii. p. 592). It is perfectly true that I have used a scalar and a vector connected with the linear vector operator, which, if combined, would form a quaternion. I have not thus combined them. Perhaps Prof. Knott will say that since I use both of them it matters little whether I combine them or not. If so I heartily agree with him.

The first charge is a little vague. I certainly admit that